

What is claimed is:

1. An extracting method of a pattern contour, comprising:
acquiring an image of a pattern to be inspected;
calculating a schematic edge position of the pattern from the image;
preparing an approximate polygon by approximating a polygon consisting of edges having predetermined direction components to a contour shape of the pattern on the basis of the calculated edge position;
dividing the approximate polygon into star-shaped polygons;
calculating the position of a kernel of the star-shaped polygon; and
searching an edge of the pattern in a direction connecting the kernel to an arbitrary point positioned on the edge of the approximate polygon.
2. The extracting method of the pattern contour according to claim 1, wherein the predetermined direction component is a direction forming an angle integer times as much as 0° to 45° with respect to a reference direction which can arbitrarily be set in the image.
3. The extracting method of the pattern contour according to claim 1, wherein said preparing the approximate polygon includes:
generating a lattice in the image, a unit cell of the lattice having a size larger than that of a pixel of the image and a weight coefficient being allocated to an edge of the lattice; and
applying a lattice animal onto the lattice based on the weight coefficient.
4. The extracting method of the pattern contour according to claim 3, wherein said preparing the approximate polygon includes:
preparing a Voronoi diagram with respect to a vertex of the lattice animal, Voronoi regions being divided by Voronoi edges of the prepared Voronoi diagram; and
synthesizing Voronoi regions which belong to the same

lattice animal, and wherein;

searching the edge of the pattern including setting a boundary of the synthesized Voronoi region as that of the edge searching.

5. The extracting method of the pattern contour according to claim 1, wherein said dividing into the star-shaped polygons includes:

dividing the approximate polygon into triangles by drawing diagonal lines which do not intersect with one another within the approximate polygon;

imparting three different pieces of label information to all the vertices of the triangles obtained by said dividing; and

selecting one arbitrary piece of the label information to mutually synthesize the triangles sharing the vertex to which the selected label information is given.

6. An extracting method of a pattern contour, comprising:
acquiring an image of a pattern to be inspected;
calculating a schematic edge position of the pattern from the image;

generating a lattice whose unit cell has a size larger than that of a pixel of the image and to whose each edge a weight coefficient is allocated on the image on the basis of the calculated edge position;

applying a lattice animal onto the lattice based on the weight coefficient; and

outputting contour data of the pattern based on coordinate data of a vertex of the applied lattice animal.

7. A program which allows a computer to implement an extracting method of a pattern contour, comprising:

acquiring an image of a pattern to be inspected;

calculating a schematic edge position of the pattern from the image;

preparing an approximate polygon by approximating a polygon

consisting of edges having predetermined direction components to a contour shape of the pattern on the basis of the calculated edge position;

dividing the approximate polygon into star-shaped polygons;

calculating the position of a kernel of the star-shaped polygon; and

searching an edge of the pattern in a direction connecting the kernel to an arbitrary point positioned on the edge of the approximate polygon.

8. A program which allows a computer to implement an extracting method of a pattern contour, comprising:

acquiring an image of a pattern to be inspected;

calculating a schematic edge position of the pattern from the image;

generating a lattice whose unit cell has a size larger than that of a pixel of the image and to whose each edge a weight coefficient is allocated on the image on the basis of the calculated edge position;

applying a lattice animal onto the lattice based on the weight coefficient; and

outputting contour data of the pattern based on coordinate data of a vertex of the applied lattice animal.

9. A manufacturing method of a semiconductor device, comprising an extracting method of a pattern contour, the extracting method comprising:

acquiring an image of a pattern to be inspected;

calculating a schematic edge position of the pattern from the image;

preparing an approximate polygon by approximating a polygon consisting of edges having predetermined direction components to a contour shape of the pattern on the basis of the calculated edge position;

dividing the approximate polygon into star-shaped polygons;

calculating the position of a kernel of the star-shaped

polygon; and

searching an edge of the pattern in a direction connecting the kernel to an arbitrary point positioned on the edge of the approximate polygon.

10. A manufacturing method of a semiconductor device, comprising an extracting method of a pattern contour, the extracting method comprising:

acquiring an image of a pattern to be inspected;

calculating a schematic edge position of the pattern from the image;

generating a lattice whose unit cell has a size larger than that of a pixel of the image and to whose each edge a weight coefficient is allocated on the image on the basis of the calculated edge position;

applying a lattice animal onto the lattice based on the weight coefficient; and

outputting contour data of the pattern based on coordinate data of a vertex of the applied lattice animal.

11. An image processing method comprising:

acquiring an image of a pattern to be inspected;

extracting a part of a point sequence which belongs to a contour of the pattern;

preparing a Voronoi diagram with respect to the extracted partial point sequence;

searching a point which belongs to an edge of the pattern along an edge of the prepared Voronoi diagram to incorporate the searched point into the partial point sequence; and

removing the edge of the Voronoi diagram intersecting with the contour of the pattern to define a sub-region in the image.

12. The image processing method according to claim 11, further comprising:

recursively repeating said preparing the Voronoi diagram, said incorporating the searched point into the partial point

sequence, and defining the sub-region in the image, with respect to at least a part of the image.

13. The image processing method according to claim 11, wherein said extracting a part of the point sequence belonging to the contour of the pattern includes: searching the edge of the pattern along an outer periphery of a whole region of the image or a pre-defined boundary of a region to be inspected in the image.

14. The image processing method according to claim 11, wherein said extracting a part of the point sequence belonging to the contour of the pattern includes: searching the edge of the pattern along a continuous line which divides a whole region of the image or a pre-defined region to be inspected in the image into two regions.

15. The image processing method according to claim 11, wherein said extracting a part of the point sequence belonging to the contour of the pattern includes: preparing a lattice having a lattice constant equal to a minimum linear width of the pattern included in a whole region of the image or a pre-defined region to be inspected in the image; and searching the contour of the pattern along the prepared lattice.

16. The image processing method according to claim 11, further comprising: comparing a geometric shape or connectivity of the Voronoi diagram or a part of the Voronoi diagram with that of another Voronoi diagram or a part of another Voronoi diagram to define a partial region of the image.

17. A program which allows a computer to implement an image processing method comprising:

- acquiring an image of a pattern to be inspected;
- extracting a part of a point sequence which belongs to a contour of the pattern;
- preparing a Voronoi diagram with respect to the extracted

partial point sequence;

searching a point which belongs to an edge of the pattern along an edge of the prepared Voronoi diagram to incorporate the searched point into the partial point sequence; and

removing the edge of the Voronoi diagram intersecting with the contour of the pattern to define a sub-region in the image.

18. A manufacturing method of a semiconductor device, comprising an image processing method including:

acquiring an image of a pattern to be inspected;

extracting a part of a point sequence which belongs to a contour of the pattern;

preparing a Voronoi diagram with respect to the extracted partial point sequence;

searching a point which belongs to an edge of the pattern along an edge of the prepared Voronoi diagram to incorporate the searched point into the partial point sequence; and

removing the edge of the Voronoi diagram intersecting with the contour of the pattern to define a sub-region in the image.

19. A searching method of a pattern edge, comprising:

acquiring an image of a pattern to be inspected and data of a line representing a schematic edge position of the pattern;

defining one arbitrary point in the image as a start point of edge searching, and defining at least one point on the line as a point in an edge searching direction; and

searching the edge of the pattern from the start point of the edge searching and along at least one curve of a curve group given by either a real part or an imaginary part of a holomorphic function, a trajectory of said curve passing through the point in the edge searching direction.

20. The searching method of the pattern edge according to claim 19, wherein said holomorphic function is analogous to a complex potential of a two-dimensional ideal fluid system which includes at least one source point and at least one sink point.

21. The searching method of the pattern edge according to claim 20, wherein said holomorphic function is analogous to a complex potential of a two-dimensional ideal fluid system in which the source point is disposed adjacent onto a finite line segment or in which the sink point is disposed adjacent onto the finite line segment or in which the source point and the sink point have a relation of a mirror image with each other with respect to the line representing the schematic edge position.

22. The searching method of the pattern edge according to claim 19, wherein said holomorphic function is analogous to a complex potential of a two-dimensional electromagnetism system which includes at least one positive point charge and at least one negative point charge.

23. The searching method of the pattern edge according to claim 22, wherein said holomorphic function is analogous to a complex potential of a two-dimensional electromagnetism system in which the positive point charge is disposed adjacent onto a finite line segment or in which the negative point charge is disposed adjacent onto the finite line segment or in which the positive point charge and the negative point charge have a relation of a mirror image with each other with respect to the line representing the schematic edge position.

24. The searching method of the pattern edge according to claim 19, wherein data of the line representing the schematic edge position is obtained based on layout data included in design data of the pattern.

25. A program which allows a computer to implement a searching method of a pattern edge, said searching method comprising:
acquiring an image of a pattern to be inspected and data of a line representing a schematic edge position of the pattern;
defining one arbitrary point in the image as a start point

of edge searching, and defining at least one point on the line as a point in an edge searching direction; and

searching the edge of the pattern from the start point of the edge searching and along at least one curve of a curve group given by either a real part or an imaginary part of a holomorphic function, a trajectory of said curve passing through the point in the edge searching direction.

26. A manufacturing method of a semiconductor device, comprising a searching method of a pattern edge, said searching method including:

acquiring an image of a pattern to be inspected and data of a line representing a schematic edge position of the pattern;

defining one arbitrary point in the image as a start point of edge searching, and defining at least one point on the line as a point in an edge searching direction; and

searching the edge of the pattern from the start point of the edge searching and along at least one curve of a curve group given by either a real part or an imaginary part of a holomorphic function, a trajectory of said curve passing through the point in the edge searching direction.

27. A method of scanning a probe onto at least a part of an observation region including a pattern to be inspected, comprising:

defining one arbitrary point in the observation region as a start point of probe scanning, and defining at least one point on a line representing the schematic edge position of the pattern as a point in a probe scanning direction; and

scanning the probe from the start point of the probe scanning and along at least one curve of a curve group given by either a real part or an imaginary part of a holomorphic function, a trajectory of the scanning passes through a point in the probe scanning direction.

28. The scanning method of the probe according to claim 27,

wherein said holomorphic function is analogous to a complex potential of a two-dimensional ideal fluid system which includes at least one source point and at least one sink point.

29. The scanning method of the probe according to claim 28, wherein said holomorphic function is analogous to a complex potential of a two-dimensional ideal fluid system in which the source point is disposed adjacent onto a finite line segment or in which the sink point is disposed adjacent onto the finite line segment or in which the source point and the sink point have a relation of a mirror image with each other with respect to the line representing the schematic edge position.

30. The scanning method of the probe according to claim 27, wherein said holomorphic function is analogous to a complex potential of a two-dimensional electromagnetism system which includes at least one positive point charge and at least one negative point charge.

31. The scanning method of the probe according to claim 30, wherein said holomorphic function is analogous to a complex potential of a two-dimensional electromagnetism system in which the positive point charge is disposed adjacent onto a finite line segment or in which the negative point charge is disposed adjacent onto the finite line segment or in which the positive point charge and the negative point charge have a relation of a mirror image with each other with respect to the line representing the schematic edge position.

32. A program to allow a computer to implement a method of scanning a probe onto a sample having an observation region, the computer controlling an inspection apparatus to generate the probe and to scan the probe onto at least a part of the observation region in which the pattern to be inspected is formed, the scanning method comprising:

defining one arbitrary point in the observation region as

a start point of probe scanning, and defining at least one point on a line representing a schematic edge position of the pattern as a point in a probe scanning direction; and

scanning the probe from the start point of the probe scanning and along at least one curve of a curve group given by either a real part or an imaginary part of a holomorphic function, a trajectory of the scanning passes through a point in the probe scanning direction.

33. A manufacturing method of a semiconductor device, comprising a method of scanning a probe onto at least a part of an observation region in which a pattern to be inspected is formed, said method of scanning the probe including:

defining one arbitrary point in the observation region as a start point of probe scanning, and defining at least one point on a line representing a schematic edge position of the pattern as a point in a probe scanning direction; and

scanning the probe from the start point of the probe scanning and along at least one curve of a curve group given by either a real part or an imaginary part of a holomorphic function, a trajectory of the scanning passes through a point in the probe scanning direction.

34. A pattern inspection apparatus comprising:

a first calculator which receives data of an image of a pattern to be inspected and calculates a schematic edge position of the pattern from the image;

an image processor which approximates a polygon constituted of edges exclusively having predetermined direction components to a contour shape of the pattern based on the calculated edge position to prepare an approximate polygon and which divides the approximate polygon into star-shaped polygons;

a second calculator which calculates a position of a kernel of the star-shaped polygon; and

an edge searcher which searches an edge of the pattern in a direction connecting the kernel to an arbitrary point positioned

on an edge of the approximate polygon.

35. A pattern inspection apparatus comprising:

a calculator which receives data of an image of a pattern to be inspected and calculates a schematic edge position of the pattern from the image;

an image processor which generates a lattice on the image based on the calculated edge position, a unit cell of the lattice having a size larger than that of a pixel of the image and a weight coefficient being allocated to each edge of the lattice, said image processor applying a lattice animal onto the lattice based on the weight coefficient; and

an edge searcher which outputs contour data of the pattern based on coordinate data of a vertex of the applied lattice animal.

36. A pattern inspection apparatus comprising:

a point sequence extractor which receives data of an image of a pattern to be inspected and which extracts a part of a point sequence belonging to a contour of the pattern;

an image processor which prepares a Voronoi diagram with respect to the extracted partial point sequence and which searches a point belonging to the edge of the pattern along an edge of the prepared Voronoi diagram to incorporate the searched point into the partial point sequence and which removes an edge of the Voronoi diagram intersecting with the contour of the pattern to define a sub-region in the image; and

an edge searcher which searches the edge of the pattern for each sub-region.

37. A pattern inspection apparatus comprising:

a setter which receives data of an image of a pattern to be inspected and data of a line representing a schematic edge position of the pattern to set a start point of edge searching and at least one point on the line as the point in an edge searching direction in the image;

a calculator to calculate a curve group which is given by

either a real part or an imaginary part of a holomorphic function and each of which passes through the point in the edge searching direction from the start point; and

an edge searcher which searches an edge of the pattern along at least one curve in the curve group.

38. A pattern inspection apparatus connectable to a probe scanning device scanning a probe onto a sample in which a pattern to be inspected is formed, the pattern inspection apparatus comprising:

a calculator which receives image data of the pattern and data of a line representing a schematic edge position of the pattern to calculate a curve group given by either a real part or an imaginary part of a holomorphic function and passing through at least one point on the line representing the schematic edge position from the start point; and

a controller which generates a control signal to scan the probe along at least one curve in the curve group and which supplies the control signal to the probe scanning device.